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(54) **ANION GENERATING AND ELECTRON CAPTURE DISSOCIATION APPARATUS USING COLD ELECTRONS**

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(58) **Field of Classification Search**
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See application file for complete search history.

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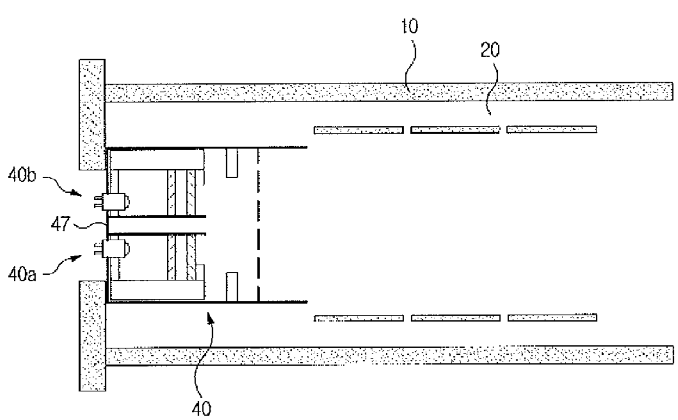
(57) **ABSTRACT**

An anion generating and electron capture dissociation apparatus using cold electrons, which comprises a cold electron generation module configured to generate a large quantity of cold electrons from ultraviolet photons radiated into a mass spectrometer vacuum chamber which is in a high vacuum state has a plurality of ultraviolet diodes configured to emit the ultraviolet photons in the mass spectrometer vacuum chamber. Micro-channel plate (MCP) electron multiplier plates induce and amplify initial electron emissions of the ultraviolet photons from the ultraviolet diodes, and generate a large quantity of electron beams from a rear plate. An electron focusing lens is configured to focus the electron beams amplified through the MCP electron multiplier plates. A grid is configured to adjust energy and an electric current of the electron beams together with the electron focusing lens.

5 Claims, 2 Drawing Sheets



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H01J 43/24	(2006.01)
H01J 49/38	(2006.01)

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FIG. 1

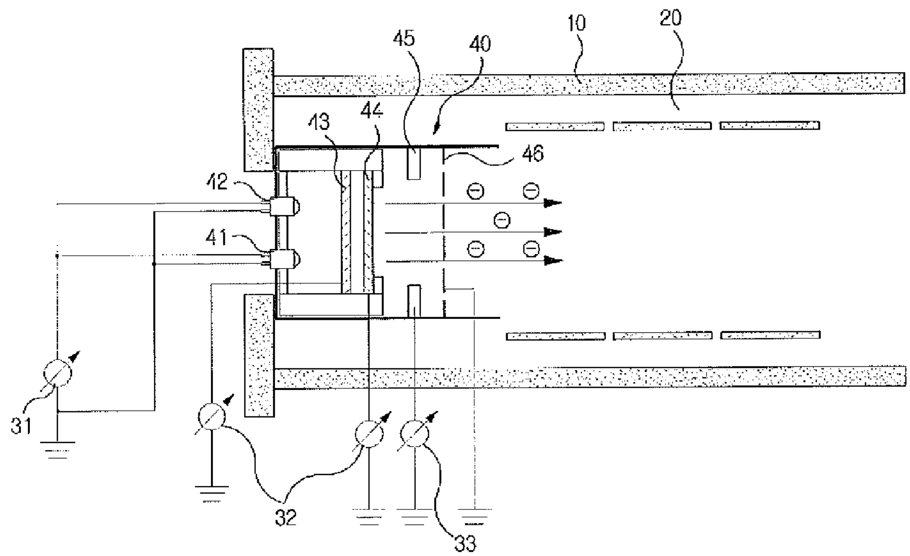


FIG. 2

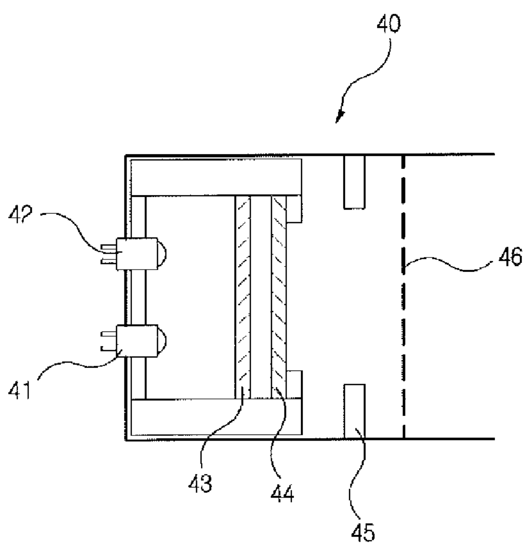


FIG. 3

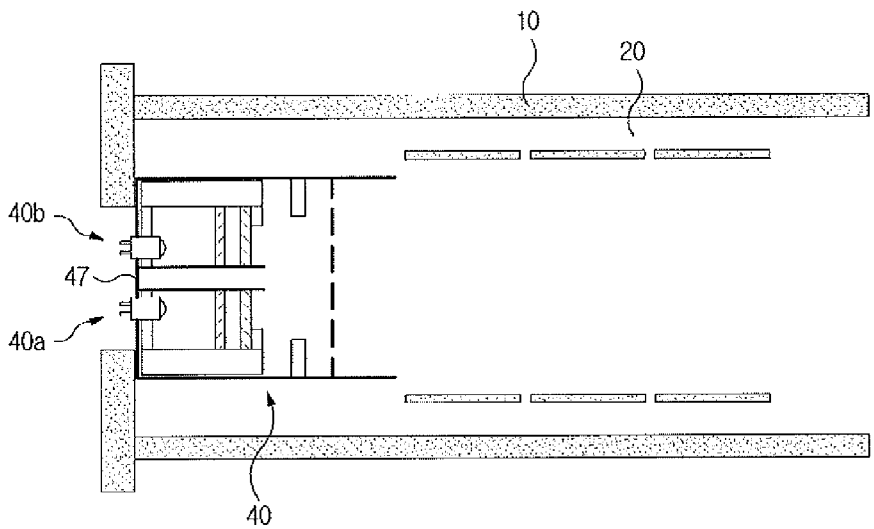
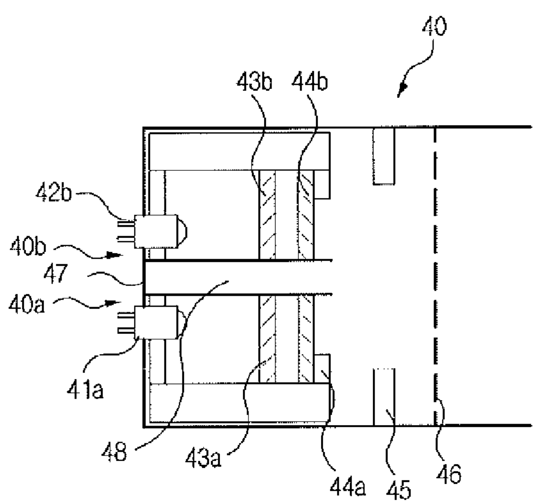


FIG. 4



ANION GENERATING AND ELECTRON CAPTURE DISSOCIATION APPARATUS USING COLD ELECTRONS

TECHNICAL FIELD

The present invention relates to an electron capture dissociation (ECD) and negative ionization apparatus which is an apparatus for injecting an cold electron beam into an ion trap of a Fourier transform ion cyclotron resonance mass spectrometer (FT-ICR MS), and more particularly, to an anion generating and electron capture dissociation apparatus using cold electrons which controls energy of an electron beam injected into an ion trap to generate anions in the ion trap, or fragments cations having multiple charges into fragment ions.

BACKGROUND ART

Generally, an ECD method is used for a Tandem mass spectrometry (MS/MS) in which peptide or protein ions having multiple positive charges are confined in an ion trap, an electron beam is injected into the ion trap, and multiple ionized molecules are coupled with electrons in the ion trap and dissociated. Further, the electrons having low energy are coupled with neutral molecules in an FT-ICR ion trap, thereby forming anions.

A trial operation of a conventional ECD apparatus should be conducted a day ahead in order to operate the apparatus, and thus a high vacuum state having a high vacuum environment of 1×10^{-7} to 1×10^{-11} torr should be prepared in the FT-ICR ion trap. Even in the case of an operation of the day, a preheating time of at least about 2 hours is required until a change in pressure due to heat generated in a heating part when generating thermoelectrons is stabilized.

Further, since a high electric current should be applied in order to heat a filament, a lot of power is consumed, and thus it is difficult to precisely control energy and an electric current in the thermoelectrons heated to a high temperature. Further, when the neutral molecules are coupled with the electrons and generate the anions, it is advantageous for the electrons to have lower energy.

DISCLOSURE

Technical Problem

The present invention is directed to providing an anion generating and electron capture dissociation apparatus using cold electrons, which uses a micro-channel plate (MCP) electron multiplier plate to generate an electron beam for ionization within an ion trap of a Fourier transform ion cyclotron resonance mass spectrometer (FT-ICR MS), injects ultraviolet photons emitted from an ultraviolet diode to the front surface of the MCP electron multiplier plate to obtain the electron beam in which the electrons are amplified by a factor of million, uses an electron focusing lens to focus and inject the electron beam into the trap, uses the ultraviolet diode and the MCP to generate the electron beam of which an emission time is precisely controlled with low temperature and low power, installs the electron focusing lens to focus the generated electron beam, and generates an ECD reaction by coupling electrons to molecules having multiple positive charges using a low energy electron beam emitting apparatus for the negative ionization of neutral molecules in the ion trap of the mass spectrometer.

Technical Solution

One aspect of the present invention provides an anion generating and electron capture dissociation apparatus using cold electrons, which comprises a cold electron generation module configured to generate a large quantity of cold electrons from ultraviolet photons radiated into a mass spectrometer vacuum chamber which is in a high vacuum state, including a plurality of ultraviolet diodes configured to emit the ultraviolet photons in the mass spectrometer vacuum chamber, micro-channel plate (MCP) electron multiplier plates which induce and amplify initial electron emission of the ultraviolet photons from the ultraviolet diodes, and generate a large quantity of electron beams from a rear plate, an electron focusing lens configured to focus the electron beams amplified through the MCP electron multiplier plates, and a grid configured to adjust energy and an electric current of the electron beams together with the electron focusing lens.

The ultraviolet diode and the MCP electron multiplier plate may be one closed module, each of which is provided in one or plural.

Advantageous Effect

The anion generating and electron capture dissociation apparatus using the cold electrons according to the present invention can be used as the cold electron generation device for the FT-ICR MS and the ion trap MS, can be applied to the negative ionization device and the ECD device, and then can be used as the negative ionization device and the ECD device which can focus a predetermined quantity of the electron beam at a desired time and inject the electron beam in the ion trap.

DESCRIPTION OF DRAWINGS

FIG. **1** is a view illustrating a configuration of an anion generating and electron capture dissociation apparatus using cold electrons according to an exemplary embodiment of the present invention.

FIG. **2** is a detailed view illustrating a configuration of a cold electron generation module of FIG. **1**.

FIG. **3** is a view illustrating a configuration of an anion generating and electron capture dissociation apparatus using cold electrons when used together with an infrared multiple photon dissociation (IRMPD) device according to another exemplary embodiment of the present invention.

FIG. **4** is a detailed view illustrating a configuration of a cold electron generation module of FIG. **3**.

MODES OF THE INVENTION

Hereinafter, a configuration and an operation of an anion generating and electron capture dissociation apparatus using cold electrons according to an exemplary embodiment of the present invention will be described in detail with reference to the accompanying drawings.

FIG. **1** is a view illustrating an entire configuration of an anion generating and electron capture dissociation apparatus using cold electrons according to an exemplary embodiment of the present invention, and FIG. **2** is a detailed view illustrating a configuration of a cold electron generation module **40**.

An anion generating and electron capture dissociation apparatus using cold electrons according to an exemplary embodiment of the present invention includes a plurality of ultraviolet diodes **41** and **42** configured to emit ultraviolet photons in a vacuum chamber **10** of a mass spectrometer, which is in a high vacuum state, micro-channel plate (MCP) electron multiplier plates **43** and **44** in which initial electron emission of the ultraviolet photons from the ultraviolet diodes **41** and **42** are induced and amplified through an front plate thereof, and a large quantity of electron beams are generated in a rear plate thereof, an electron focusing lens **45** configured to focus the electron beams amplified through the MCP electron multiplier plates **43** and **44**, and a grid **46** configured to adjust energy and an electric current of electrons together with the electron focusing lens **45**, an ion trap **20** configured of a plurality of electrodes to detect an ion injected through the grid **46**, and power supplying devices **31**, **32** and **33** configured to supply pulse power to each of the ultraviolet diodes **41** and **42**, the MCP electron multiplier plates **43** and **44** and the electron focusing lens **45**.

Here, at least one or more ultraviolet diodes **41** and **42** may be used.

An operation of the present invention as described above will be described in detail.

First, an emission time and an intensity of the ultraviolet photons generated from the ultraviolet diodes **41** and **42** are adjusted by the supplied on/off pulse signal of the power.

That is, as a continuous time of the pulse power supplied by the ultraviolet diode power supplying device **31** and a value of an electric current applied to the ultraviolet diodes **41** and **42** through the pulse power are controlled, the emission time and the intensity of the ultraviolet photons are controlled.

The ultraviolet photons generated from the ultraviolet diodes **41** and **42** are injected to the front plate **43** of the MCP electron multiplier plates **43** and **44**, and amplified. Then, a large quantity of electrons (an amplification factor of 10^6) is generated through the rear plate **44**.

The election beam amplified through the rear plate **44** of the MCP electron multiplier plates **43** and **44** is focused according to a voltage value of the electron focusing lens **45**, and moves toward the grid **46**. The grid **46** forms an electric field which serves to adjust the energy and the electric current of the electron beam together with the electron focusing lens **45**. When the voltage value of the grid **46** is lower than that of the MCP electron multiplier plate, the generated electrons have straightness and are injected into the ion trap **20**.

The ion trap **20** is an open trap, and low energy electrons injected therein react with neutral molecules, induce negative ionization of the neutral molecules, undergo an ECD reaction by being coupled with cations having multiple positive charges, and inducing ion fragmentization. Thus, information on a structural analysis of the ions is provided.

In order to perform each operation of the MCP electron multiplier plates **43** and **44**, the electron focusing lens **45** and the grid **46**, which amplifies and focuses the ultraviolet photons generated from the ultraviolet diodes **41** and **42** and injects the ions having straightness into the ion trap **20**, the inside of the vacuum chamber **10** should be maintained in a high vacuum state of 1×10^{-7} to 1×10^{-11} torr.

FIG. **3** is a view illustrating a configuration of an anion generating and electron capture dissociation apparatus using cold electrons according to another exemplary embodiment of the present invention, and FIG. **4** is a detailed view illustrating a configuration of a cold electron generation module of FIG. **3**. When used together with an infrared multiple photon dissociation (IRMPD) device, it is necessary to form a hole at a center of the MCP multiplier plate, such that infrared light may pass therethrough. And as illustrated in FIG. **4**, cold electrons are generated from a surface of the MCP multiplier plate except for the central hole of the MCP multiplier plate.

Therefore, as illustrated in the drawings, the cold electron generation module **40** is divided into first and second cold electron generation modules **40***a* and **40***b*. Each of the first and second cold electron generation modules **40***a* and **40***b* includes ultraviolet diodes **41***a* and **42***a*, MCP electron multiplier plates **43***a*, **43***b*, **44***a* and **44***b*, an infrared light transmitting window **47** disposed between the divided first and second cold electron generation modules **40***a* and **40***b* to transmit external infrared light into the vacuum chamber **10**, and an infrared light guide tube **48** configured to maintain a route of the infrared light passing through the infrared light transmitting window **47**. A plurality of each of the ultraviolet diodes **41***a* and **42***a* may be provided.

Here, the infrared light transmitting window **47** is configured of a transparent window disposed between the atmosphere and the vacuum chamber **10** so that an infrared laser is transmitted into the vacuum chamber. Also, the infrared light transmitting window **47** is vacuum-sealed so that the vacuum chamber **10** is maintained in the vacuum state.

The infrared light guide tube **48** is formed in an elongated cylindrical nonconductive structure which is used as a pass route of the infrared light passing through the infrared light transmitting window **47**. Also, the infrared light guide tube **48** serves to support each of structures of the cold electron generation modules **40***a* and **40***b*, and also prevents the cold electron generation modules **40***a* and **40***b* from being damaged by the infrared laser.

The ultraviolet photons generated from the first and second cold electron generation modules **40***a* and **40***b* inject cold electrons having straightness into the ion trap **20** through the electron focusing lens **45** and the grid **46**.

Hereinafter, since specific operations of the divided first and second cold electron generation modules **40***a* and **40***b* are the same as those of the detailed description of FIGS. **1** and **2**, reference will be made thereto.

Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

The invention claimed is:

1. An anion generating and electron capture dissociation apparatus using cold electrons, which comprises a cold electron generation module configured to generate a large quantity of cold electrons from ultraviolet photons radiated into a mass spectrometer vacuum chamber which is in a high vacuum state, comprising:

a plurality of ultraviolet diodes configured to emit the ultraviolet photons in the mass spectrometer vacuum chamber;

a micro-channel plate (MCP) electron multiplier plates which induce and amplify initial electron emission of the ultraviolet photons from the ultraviolet diodes, and generate a large quantity of electron beams from a rear plate;

an electron focusing lens configured to focus the electron beams amplified through the MCP electron multiplier plates; and

a grid configured to adjust energy and an electric current of the electron beams together with the electron focusing lens;

wherein the cold electron generation module is divided into a plurality of cold electron generation modules, and the divided cold electron generation modules are used together with an infrared multiple photon dissociation (IRMPD) device, the MCP electron multiplier plate comprising an infrared light transmitting window disposed between the divided cold electron generation modules to transmit external infrared light into the vacuum chamber, and an infrared light guide tube configured to maintain a route of the infrared light passing through the infrared light transmitting window.

2. The apparatus of claim **1**, wherein the ultraviolet diodes control an emission time and an intensity of ultraviolet light according to an on/off pulse signal of supplied power.

3. The apparatus of claim **1**, wherein the grid controls energy and an electric current of electrons generated from the MCP electron multiplier plate.

4. The apparatus of claim **1**, wherein low energy electrons generated from the MCP electron multiplier plate react with neutral molecules and generate anions.

5. The apparatus of claim **1**, wherein the cold electron generation module is divided into a plurality of cold electron generation modules, and each of the divided cold electron generation modules comprises the ultraviolet diodes and the MCP electron multiplier plate.

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